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ABSTRACT

This study focuses on the possible relationships between cognitive preference scores of algebra students and level of algebra, sex, and performance rank in algebra classes. The sample consisted of 162 students from a high school in the Denver area. The instruments used were the Cognitive Preference Test: Mathematics (Revised) (CPTM) and the Cognitive Preference Examination-II) (CPE-II). The results of the study indicated: (1) there were no differences in the CPTM preference scores of students when grouped by grade level and performance rank; (2) the analysis of the CPE-II scores failed to yield significant insights, which led the researchers to speculate that these preference modes are not as important in the study of mathematics as they are in other disciplines; and (3) although several interaction effects were found to exist, their meaning and implications were unclear to the investigators. Numerous data tables are included. (TW)

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COGNITIVE PREFERENCES OF ALGEBRA STUDENTS ACROSS GRADE AND ABILITY LEVELS

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INTRODUCTION

While the literature abounds with cognitive preference research in the sciences, this type of research in mathematics is seldom reported. There are two major studies in this area though.

O'Donnell (1975) studied the effects of student and teacher cognitive preferences on achievement in junior high school mathematics. As a result of this study the following conclusions were made:

1) The interaction between teacher and student cognitive preferences does not have a significant effect on either computation or concept achievement.
2) The cognitive preference of the student has no significant effect on either computation or concept achievement.
3) The cognitive preference of the teacher has no significant effect on computation achievement. The teacher's cognitive preference may have an effect on concept achievement, however, with the students of "symbolic" teachers achieving slightly higher.

Using the same cognitive preference test as O'Donnell, Endsley (1983) studied the effects of cognitive preference, sex, and attitude toward mathematics on achievement in a first-year algebra course. He concluded that a student's cognitive preference for learning mathematical facts was not significantly related to achievement. He did find, though,

that females achieve at a higher level than males in first-year algebra and that a positive mathematical attitude is significantly related to achievement.

After reviewing the results of their own studies and the cognitive preference literature, the authors decided to focus their attention on the following questions:

1) Is there a significant difference in the cognitive preference scores of algebra students when they are classified by level of algebra, sex, and performance rank in algebra class?
2) Is there an interaction effect of algebra level, sex, and performance rank on cognitive preference scores?

SAMPLE

The sample consisted of 162 students from one high school in the Denver metropolitan area. The student population at this school is 80% college bound. During the 1985-86 school year the senior class scored an average composite of 21.4 on the ACT tests and an average SAT score of 461 on the verbal section and 519 on the math section.

For the purpose of this study there were 2 sections of each of three one-year courses (Pre-Algebra, Algebra 1, and Algebra 2). Both sections of each course were taught by one teacher.

PROCEDURE

The Cognitive Preference Test: Mathematics (Revised) (CPTM) and the Cognitive Preference Examination-II (CPE-II) were administered during early February, 1986. The students were ranked by their semester grades which were computed during the first week of June, 1986.

The CPE-II was administered as a check on the validity of the CPTM. Although 2 studies using the CPTM (O'Donnell, Endsley) have yielded no significant results, Atwood and Rogers (1974), Barnett (1974), and Atwood and Stevens (1978) had significant results using the CPE-II.

The CPTM is a thirty-two item revision of an earlier test (Travers, Heath, and Cahen, 1967). The content is math specific. Content validity was established by a panel of experts. The test yields an ipsative score for graphic, verbal, and symbolic choices. O'Donnell (1975) reported reliability coefficients (Spearman-Brown "Prophecy Formula") of .91 for the graphic preference, .91 for the verbal preference, and .90 for the symbolic preference. Mean cognitive preference scores obtained in this study for the experimental sample were 3.819, 6.249, and 21.816 for the Graphic, Verbal, and Symbolic preferences respectively.

The CPE-II is a thirty item, discipline-free, test which yields ipsative scores for three preference options: (1) Application, (2) Memory, and (3) Questioning. Atwood (1971) reported reliability coefficients of .77, .70, and .74 for the Application, Memory, and Questioning preferences

respectively. Mean cognitive preference scores obtained in the present study for the experimental sample were 9.073, 10.148, and 7.764 for Memory, Application, and Questioning.

In previous cognitive preference research (Atwood, 1967-68; Barnett, O'Donnell, Atwood and Stevens, Endsley) the subjects were classified on the basis of their cognitive preference scores. Some measure of achievement was then used as the dependent variable. This technique resulted in the exclusion of students of all ability levels who may have been equally comfortable using any of the preference options. The present investigators felt that this exclusion of subjects could adversely skew the population and mask statistically significant relationships. For purposes of this study the student's cognitive preference scores were used as the dependent variable. The student's performance rank, sex, and algebra level were used as the independent variables.

Students were ranked in quartiles based on their semester percentages. For the purpose of this report Q1 denotes the highest quartile while Q4 denotes the lowest quartile. The cut-off scores between Q1 and Q2 and between Q2 and Q3 were within 2 percentage points of each other for all courses. The cut-off for Q3 and Q4 were within 2 percentage points for the Pre-Algebra and Algebra 1 class. The break between Q3 and Q4 for the Algebra 2 class was approximately 5 percentage points higher. This can be explained by the natural selection process which occurs between the Algebra 1 and Algebra 2 courses. The

investigators felt that discrepancies could be considered further if any significant results were identified. Due to attendance problems, Q4 was omitted for the CPE-II test.

A 3-factor analysis of variance (ANOVA) model was used to investigate effects of the independent variables and their interactions on the dependent variable. The original experimental cell sizes were unequal. Glass and Stanley (1970, p.439) suggest that when cell sizes are unequal that a small number of scores be randomly discarded in order to obtain equal or proportional cell sizes. Equal cell sizes were used in this study. There were 42 null hypotheses tested for significance at the .05 level.

RESULTS

The results of the ANOVA for the CPTM are reported in Tables 1, 2, and 3. The results of the ANOVA for the CPE-II are reported in Tables 4, 5, and 6. An examination of Table 3 reveals a significant (.05 level) interaction effect of class level and sex on symbolic preference scores. Figure 1 shows the nature of this interaction. Table 1 indicates a possible sex effect on graphic scores. The mean male graphic score was 4.833 while the mean female score was 2.805.

Table 5 reveals a significant (.05 level) interaction effect of sex and quartile rank on application preference scores. Figure 2 shows the nature of this interaction. Table 6 indicates the possibility that class level and

quartile rank interact to effect questioning preference scores. Figure 3 shows the result of this interaction.

DISCUSSION AND IMPLICATIONS

The results of this study ran counter to what the investigators expected. The investigators felt that the more experienced algebra students would display a greater preference for symbolic representation, given their longer exposure to symbolic material, as would the more successful students, given the intensely symbolic nature of Algebra. Contrary to these assumptions, there was no difference in the CPTM preference scores of students when grouped by grade level and performance rank. Apparently, cognitive preferences do not change during the high school years. It is possible that they are determined by age 15, or earlier, and do not change unless an intense effort is made to change them. This is an area for possible research.

The fact that there is no satistical difference in preference scores of students classified by performance rank would seem to be consistent with the earlier results of O'Donnell and Endsley. In none of these studies has a statistical relationship been found between cognitive preferences and mathematical performance. With mean scores of 3.819, 6.249, and 21.816 for the Graphic, Verbal, and Symbolic modes, respectively, it appears that all students have been strongly influenced toward the symbolic preference. It may be that mathematical cognitive

preferences reflect the nature of the majority of text books or possibly other influences. Another area of possible research would be to investigate the development of this overwhelming preference for symbolic representation without concurrent differentiation of performance.

The analysis of the CPE-II scores failed to yield significant insights. It had been expected that the CPE-II might reveal significant effects as it had in other disciplines. This did not prove to be the case. Apparently, these preference modes are not as important in the study of mathematics as they are in other disciplines. Why this is so is open to conjecture.

Although several interaction effects were found to exist, their meaning and implications are unclear to the investigators. They may prove to be a point of departure for further research.

The investigators would also suggest that this study be replicated with a population that is more diverse. A limited number of copies of the CPTM are available from the authors for research purposes.

Results of ANOVA for Graphic Preference

Source of Variance	Sum of Squares	Degrees of Freedom	Mean Square	F Value
Class	68.5277	2	34.2638	1.7799
Sex	74.0138	1	74.0138	3.8448**
Quartile Rank	56.7083	3	18.9027	.98196
Class X Sex	88.8611	2	44.4305	2.308
Class X Quartile Rank	26.25	6	4.375	.22727
Sex X Quartile Rank	80.375	3	26.7916	1.3917
Class X Sex X Quartile Rank	43.9166	6	7.31944	.38023
Error	924	48	19.25	

** significant at .10 level

Table 1

Results of ANOVA for Verbal Preference

Source of Variance	Sum of Squares	Degrees of Freedom	Mean Square	F Value
Class	105.249	2	52.6249	1.3733
Sex	6.72222	1	6.72222	.17542
Quartile Rank	225.611	3	75.2037	1.9625
Class X Sex	94.6944	2	47.3472	1.2355
Class X Quartile Rank	342.638	6	57.1064	1.4902
Sex X Quartile Rank	205.611	3	68.537	1.7885
Class X Sex X Quartile Rank	309.638	6	51.6064	1.3467
Error	1839.33	48	38.3194	

Table 2

Results of ANOVA for Symbolic Preference

Source of Variance	Sum of Squares	Degrees of Freedom	Mean Square	F Value
Class	203.444	2	101.722	2.0338
Sex	37.5555	1	37.5555	.7509
Quartile Rank	283.277	3	94.4259	1.8879
Class X Sex	325.777	2	162.888	3.2568*
Class X Quartile Rank	241.555	6	40.2592	.80496
Sex X Quartile Rank	158.666	3	52.8888	1.0574
Class X Sex X Quartile Rank	259.666	6	43.2777	.86531
Error	2400.66	48	50.0138	

* Significant at .05 level

Table 3

Results of ANOVA for Memory Preference

Source of Variance	Sum of Squares	Degrees of Freedom	Mean Square	F Value
Class	.036142	2	.018071	.035485
Sex	8.96295	1	8.96295	1.7599
Quartile Rank	5.59259	2	2.79629	.54909
Class X Sex	4.92682	2	2.46341	.48372
Class X Quartile Rank	13.7416	4	3.4354	.67458
Sex X Quartile Rank	10.7037	2	5.35185	1.0509
Class X Sex X Quartile Rank	22.4065	4	5.60162	1.0999
Error	183.333	36	5.09259	

Table 4

Results of ANOVA for Application Preference

Source of Variance	Sum of Squares	Degrees of Freedom	Mean Square	F Value
Class	29.4814	2	14.7407	1.7927
Sex	.296297	1	.296297	.03603
Quartile Rank	8.48147	2	4.24073	.51576
Class X Sex	11.2592	2	5.62963	.68468
Class X Quartile Rank	38.5185	4	9.62963	1.1711
Sex X Quartile Rank	59.1481	2	29.574	3.5968 *
Class X Sex X Quartile Rank	13.6296	4	3.4074	.41441
Error	296	36	8.22222	

* Significant at .05 level

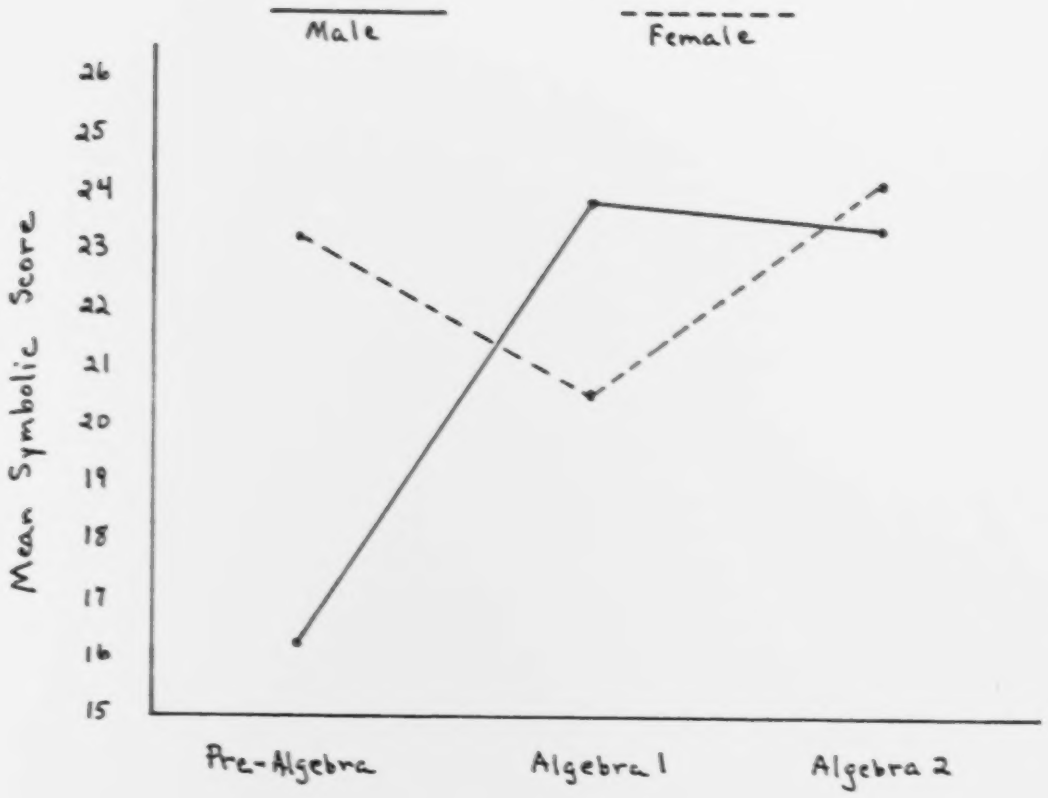
Table 5

Results of ANOVA for Questioning Preference

Source of Variance	Sum of Squares	Degrees of Freedom	Mean Square	F Value
Class	27.4444	2	13.7222	1.7034
Sex	5.99999	1	5.99999	.74482
Quartile Rank	.33333	2	.166665	.02068
Class X Sex	7.44444	2	3.72222	.46206
Class X Quartile Rank	62.8888	4	15.7222	1.9517 **
Sex X Quartile Rank	20.1111	2	10.0555	1.2482
Class X Sex X Quartile Rank	35.1111	4	8.77777	1.0896
Error	289.999	36	8.05555	

** Significant at .10 level

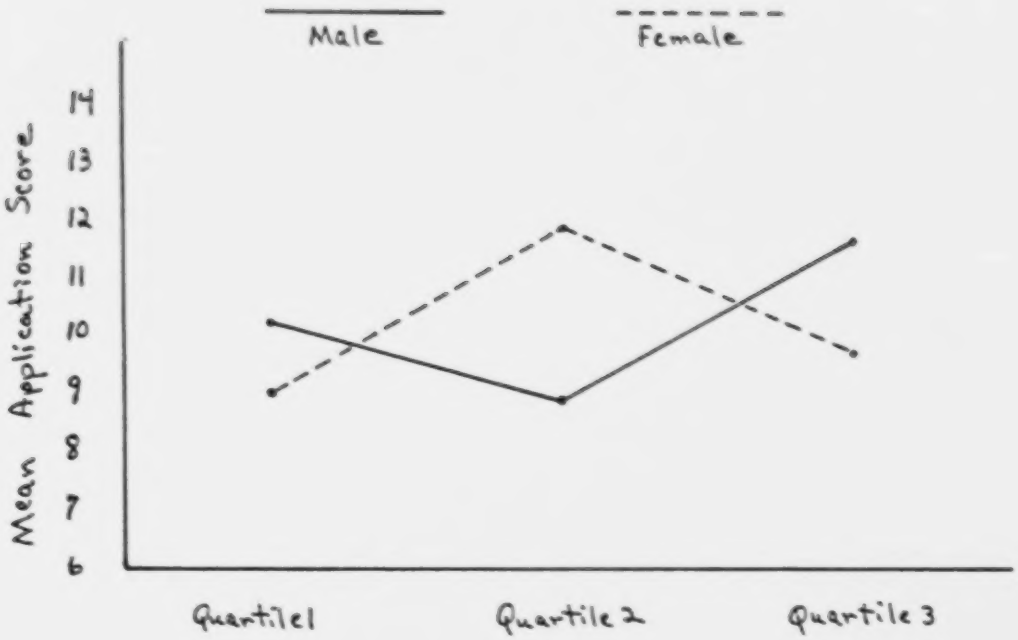
Table 6



MEAN SYMBOLIC SCORES

PRE-ALGEBRA	ALGEBRA 1	ALGEBRA 2
Male - 16.167 Female - 23.167	Male - 23.833 Female - 20.500	Male - 23.417 Female - 24.083

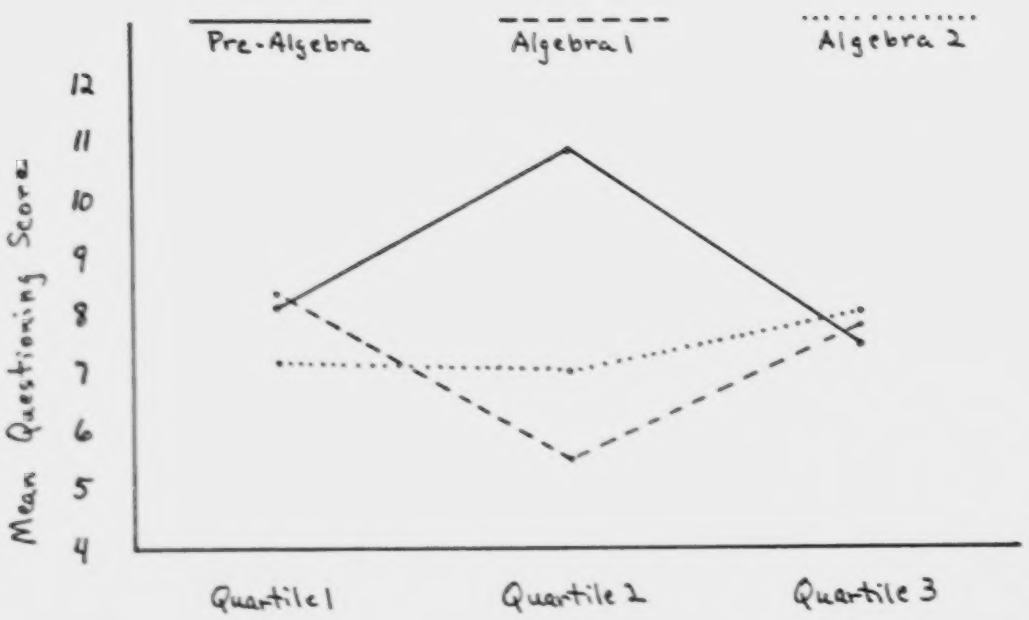
Figure 1



MEAN APPLICATION SCORES

QUARTILE 1	QUARTILE 2	QUARTILE 3
Male - 10.222 Female - 9.000	Male - 8.889 Female - 11.667	Male - 11.556 Female - 9.556

Figure 2



MEAN QUESTIONING SCORES

QUARTILE 1	QUARTILE 2	QUARTILE 3
PA - 8.167	PA - 10.667	PA - 7.550
A1 - 8.333	A1 - 5.500	A1 - 7.667
A2 - 7.167	A2 - 7.000	A2 - 8.000

Figure 3

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